(No Model.) 6 Sheets—Sheet 1.

L. HALVORSON.

EXPLOSIVE ENGINE.

No. 600,147. Patented Mar. 8, 1898.

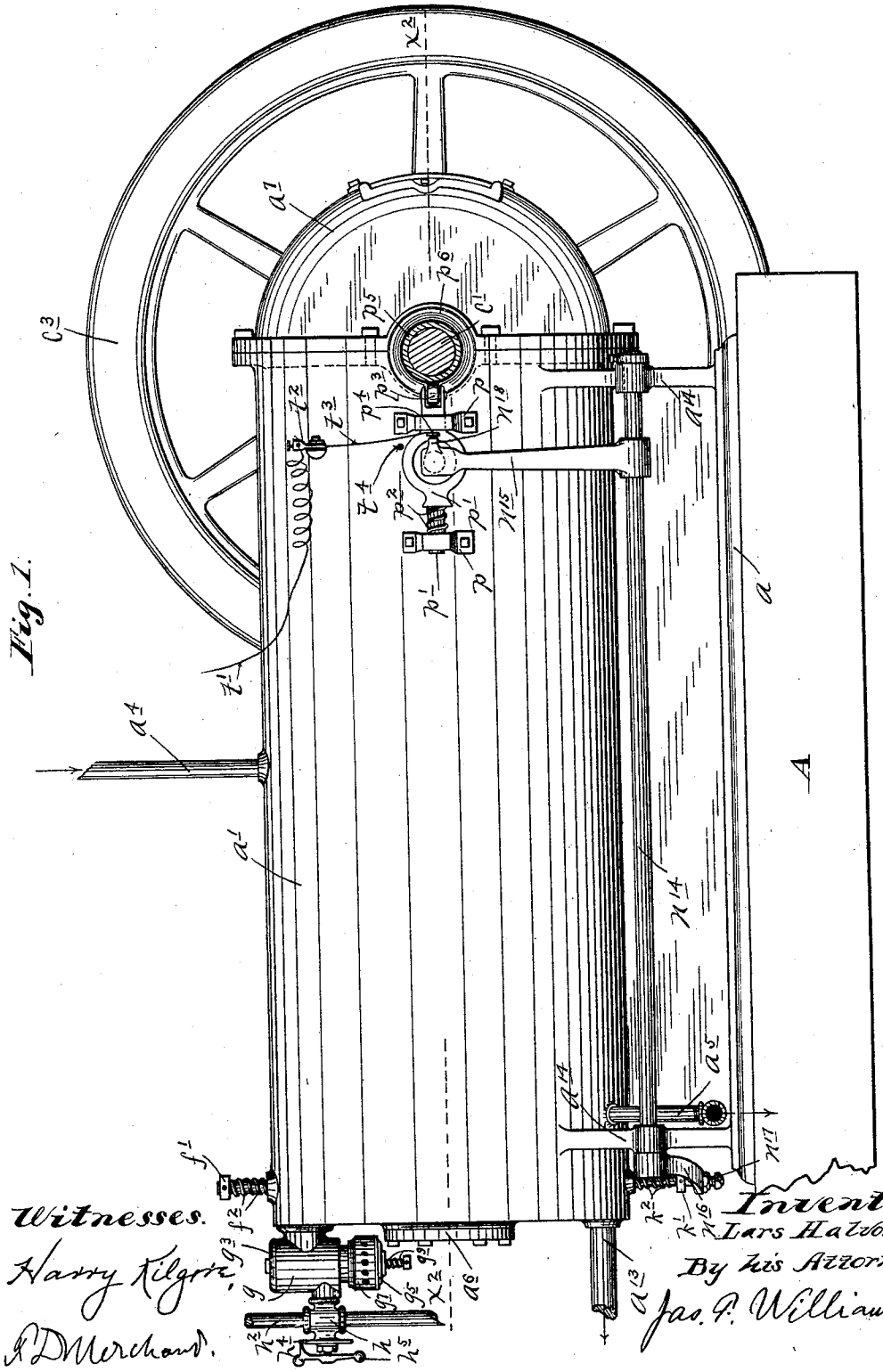

Fig. 1.

Witnesses.
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R. D. Merchant.

Inventor:
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By his Attorney.
Jas. F. Williamson

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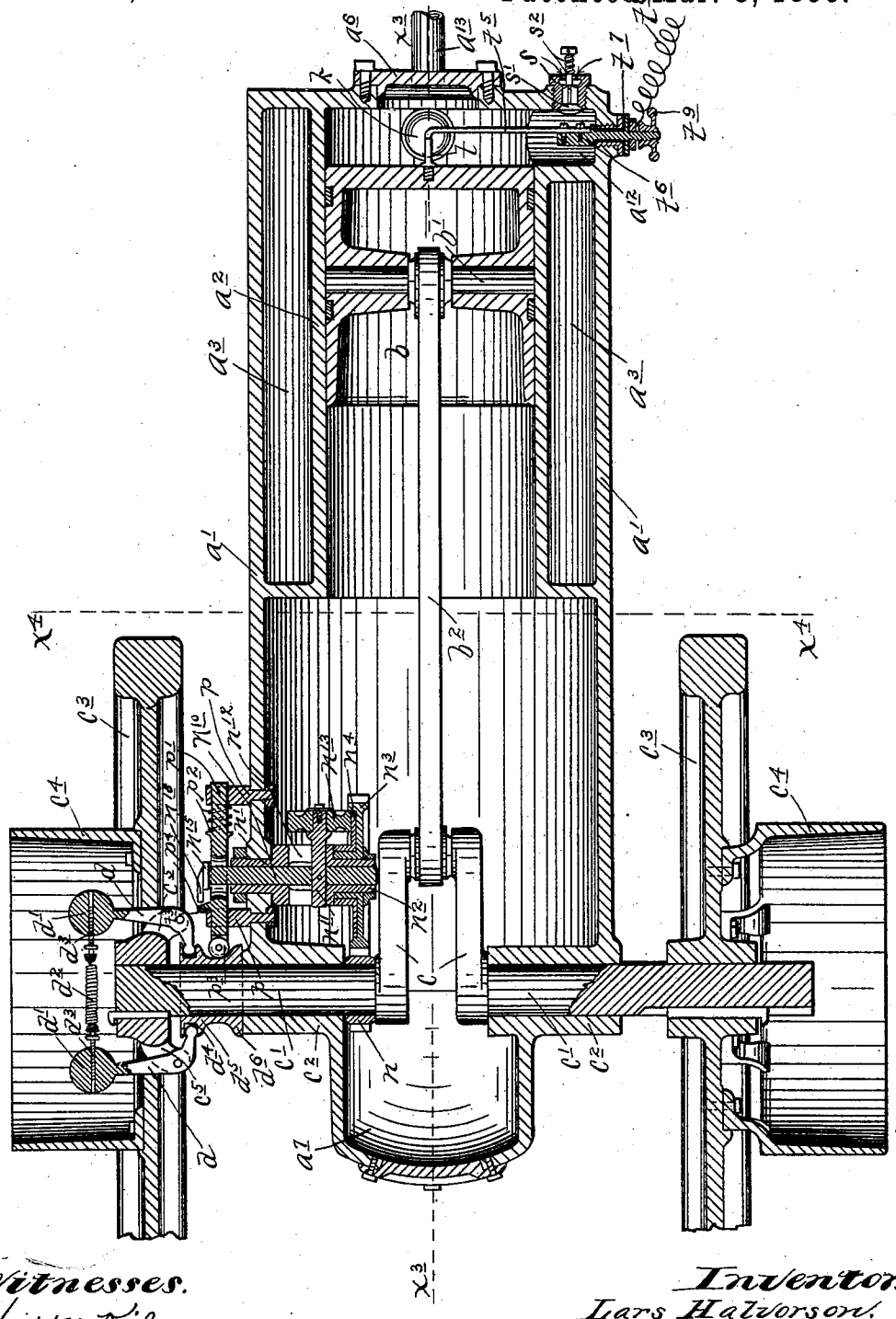

Fig. 2.

Witnesses.
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L. HALVORSON.

EXPLOSIVE ENGINE.

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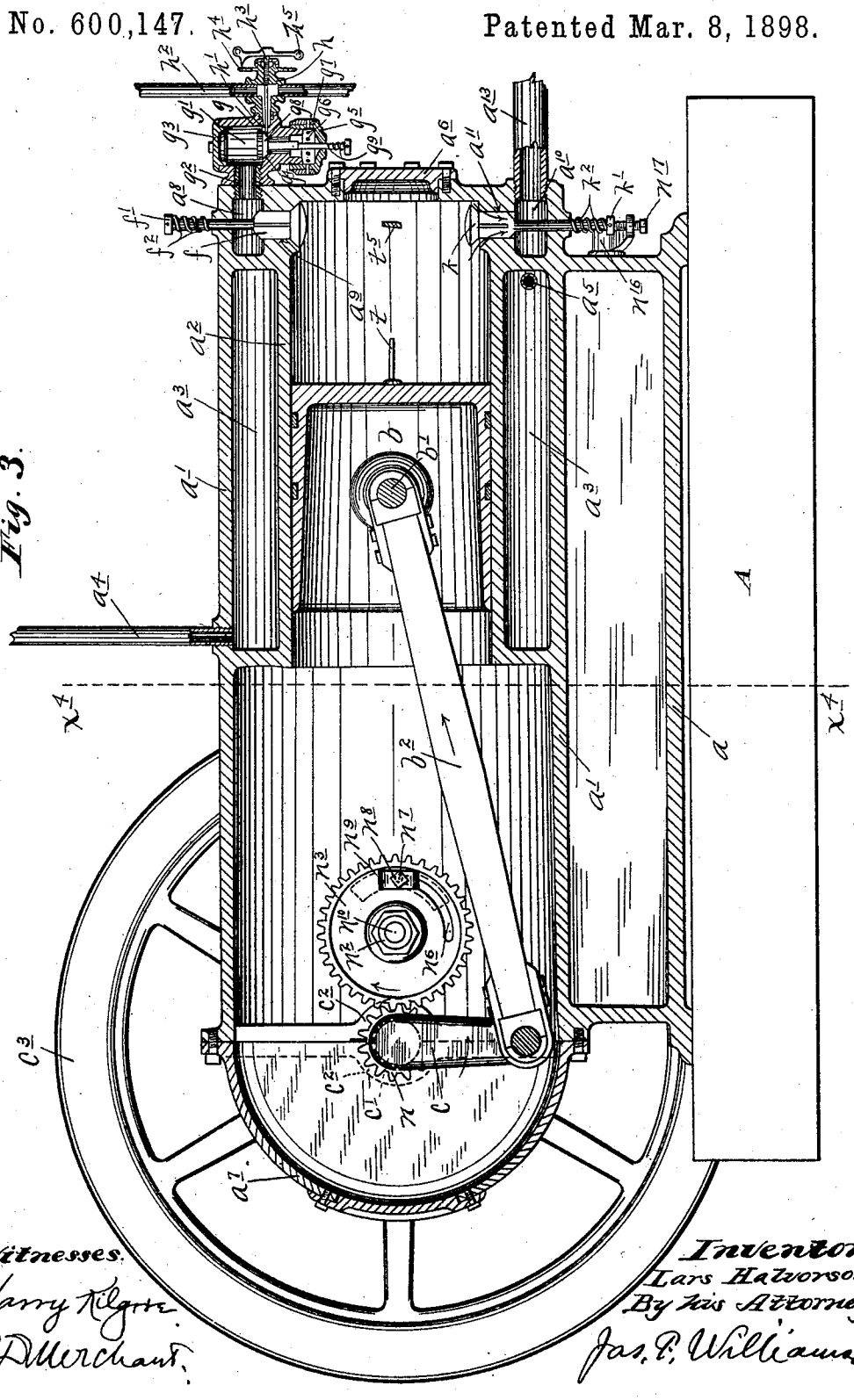
Fig. 3.



Witnesses.
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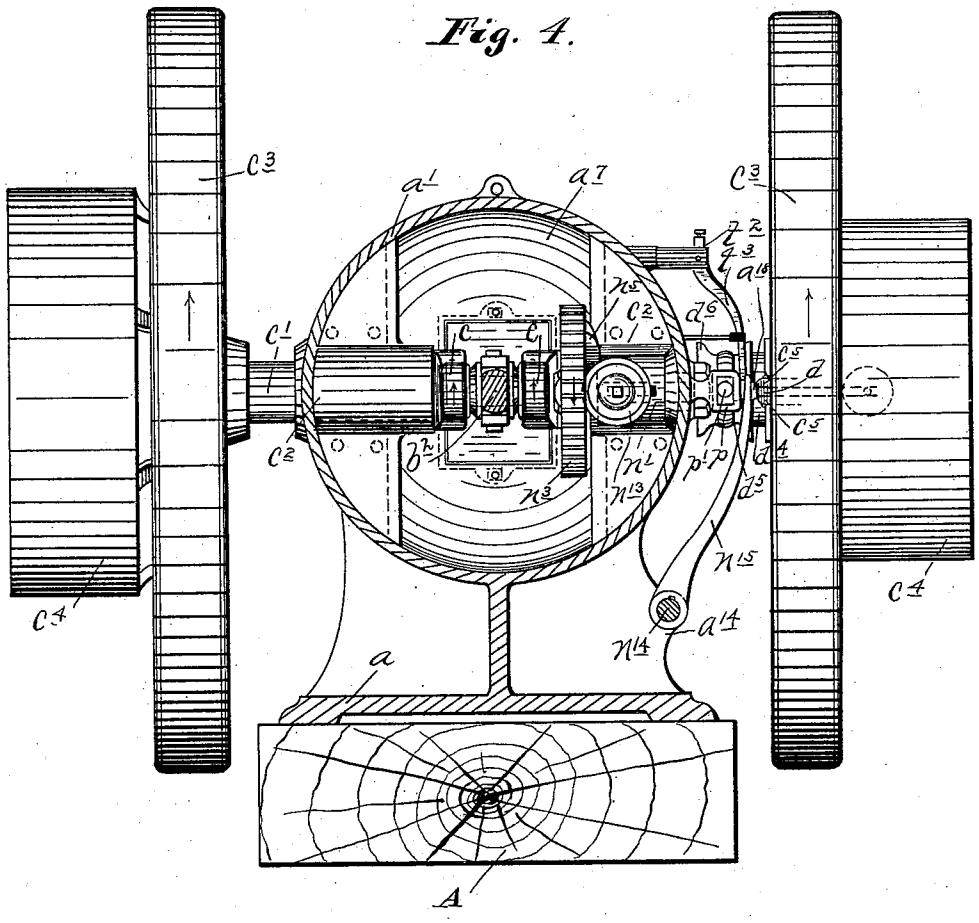
L. HALVORSON.

EXPLOSIVE ENGINE.

No. 600,147. Patented Mar. 8, 1898.

Fig. 4.



Witnesses.
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(No Model.) 6 Sheets—Sheet 5.

L. HALVORSON.

EXPLOSIVE ENGINE.

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Fig. 5.

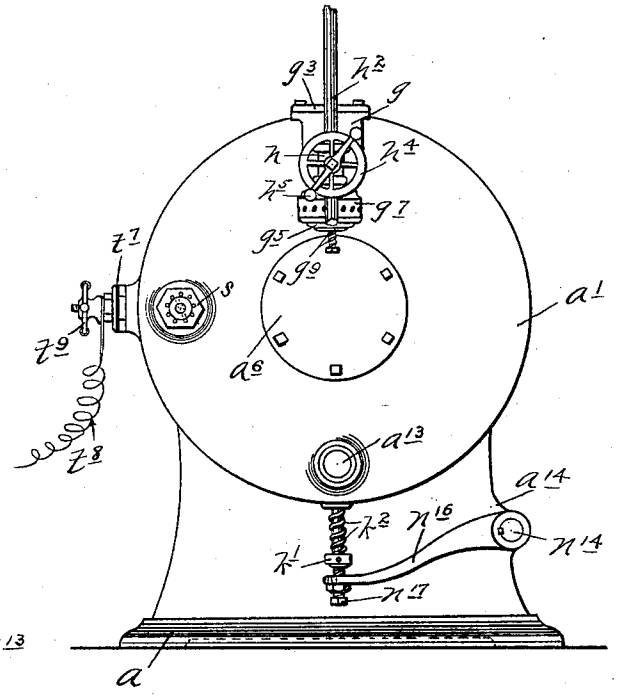


Fig. 6.

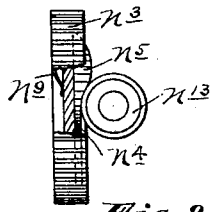


Fig. 7.

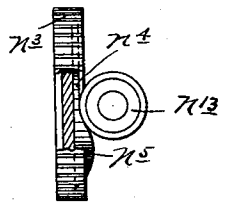


Fig. 8.

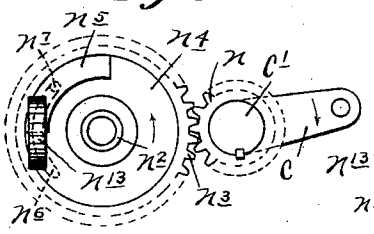


Fig. 9.

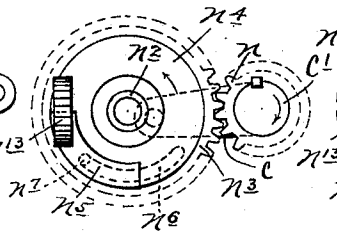


Fig. 10.

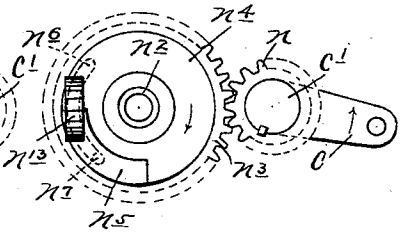
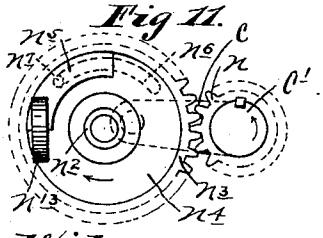


Fig 11.



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(No Model.) 6 Sheets—Sheet 6.

L. HALVORSON.

EXPLOSIVE ENGINE.

No. 600,147. Patented Mar. 8, 1898.

Fig. 12.

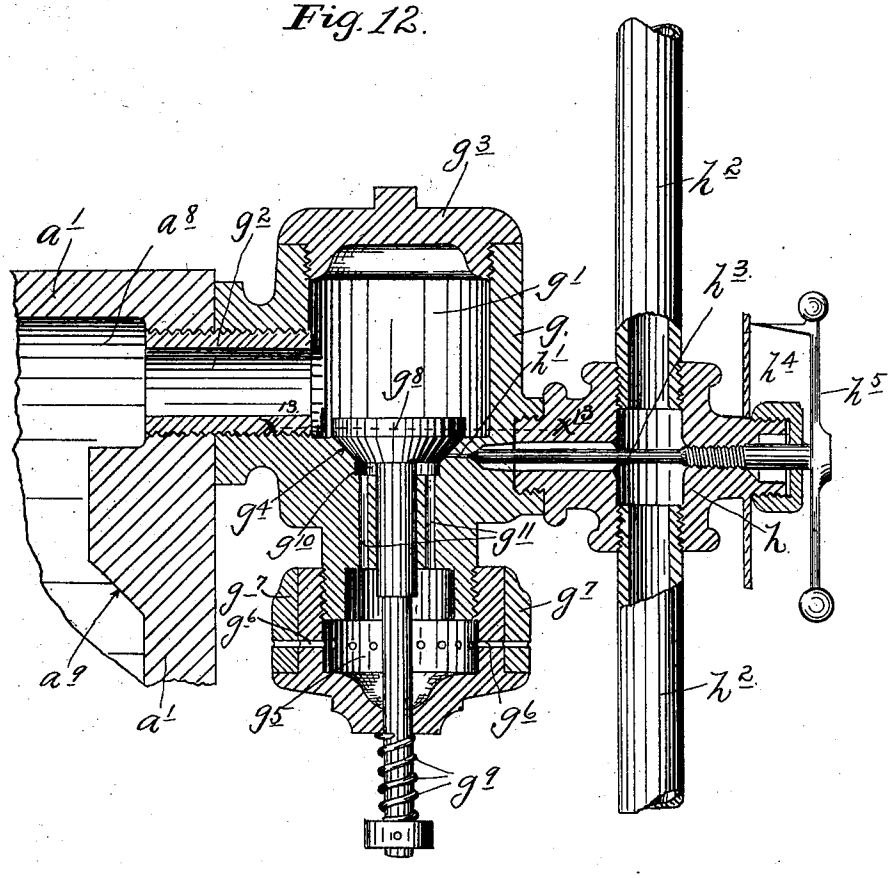
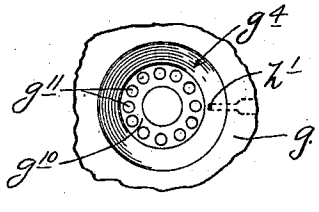


Fig. 13.



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R. D. Merchant.

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Lars Halverson
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UNITED STATES PATENT OFFICE.

LARS HALVORSON, OF WILMAR, MINNESOTA.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 600,147, dated March 8, 1898.

Application filed July 9, 1896. Serial No. 598,507. (No model.)

To all whom it may concern:

Be it known that I, LARS HALVORSON, a citizen of the United States, residing at Wilmar, in the county of Kandiyohi and State of Minnesota, have invented certain new and useful Improvements in Explosive-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to explosive-engines, such as gas and oil engines, and has for its object to simplify and improve the construction of the same with a view of decreased cost, greater durability, and increased efficiency.

To these ends my invention comprises the novel devices and combinations of devices hereinafter described, and defined in the claims.

The preferred form of my invention is illustrated in the accompanying drawings, wherein like letters refer to like parts throughout the several views.

Figure 1 is a view principally in left side elevation, but showing one of the fly-wheels of the engine removed and the shaft of the same sectioned. Fig. 2 is a horizontal section through the engine, taken substantially on a line $x^2\ x^2$ of Fig. 1. Fig. 3 is a vertical longitudinal section taken substantially on a line $x^3\ x^3$ of Fig. 2. Fig. 4 is a vertical transverse section taken substantially on the lines $x^4\ x^4$ of Figs. 2 and 3, looking toward the rear of the engine or in the direction of the crank-shaft. Fig. 5 is an end elevation looking at the front or cylinder end of the engine. Figs. 6 and 7 are detail views, in front elevation, with some parts broken away, showing a portion of the valve-gear of the engine. Figs. 8 to 11, inclusive, are views, partly in left side elevation and partly in diagram, illustrating the action of the valve-gear at different points of the piston and crank-arm's strokes. Fig. 12 is a view, principally in vertical section, corresponding to Fig. 3, but with some parts shown in full, illustrating, on an enlarged scale, the so-called "commingling-chamber" and valve-passage thereto; and Fig. 13 is a horizontal section, with some parts broken away, taken substantially on the line $X^{13}\ X^{13}$ of Fig. 12.

On a suitable foundation A is mounted the base a of the engine, cast integral with which is a large horizontally-disposed cylindrical casing or drum a'. As shown, the cylinder proper, a^2, is also cast integral with the said base a and casing a', and the walls of the same are spaced apart from the interior walls of said drum to form a water-tight circulating-chamber or jacket a^3. As shown, cold water may be kept circulating through said chamber a^3 by means of a pair of pipe connections a^4 and a^5, which tap the same, respectively, from the top and bottom portion of the casing a'.

The outer end of the cylinder a^2 is provided with a small removable head a^6, and the open end of the extended portion of the portion a' is closed by means of a dome-like head a^7.

In the upper portion of the outer end of the cylinder-casting is formed a valve-chamber a^8, which is in communication, through a valve-passage a^9, with the interior of the cylinder a^2. The lower portion of the outer end of the cylinder-casting is likewise formed with a valve-chamber a^{10}, which is in communication, through a valve-passage a^{11}, with the interior of the cylinder a^2. Again, the outer end of the cylinder-casting is formed with a laterally-extended chamber a^{12}, the function of which, as well as of the chambers a^8 and a^{10} and valve seats or passages a^9 and a^{11}, will later appear.

The cylinder a^2 is fitted with a trunk-piston b of sufficient length to also serve as a cross-head. The piston b is connected directly, by means of a cross-head pin b' and main rod b^2, with the crank c of the engine. As shown, the engine-crank c is formed at the intermediate portion of the transverse crank-shaft c', which is mounted in suitable bearings c^2, formed partly in the end of the drum or casing a' and partly in the cap a^7. It will be noted that the crank c and main rod b^2 work entirely within the casing formed by the drum a' and cap a^7.

As shown, both of the extended ends of the crank-shaft c' are provided with rigidly-secured fly-wheels c^3, which in turn are provided with pulleys c^4, over which belts (not shown) may be run to transmit the power and motion from the engine. The hub of the left member of the fly-wheel c^3 is provided with a pair of lugs or ears c^5, to each of which is pivoted the elbow of a bell-crank lever d.

These levers d are provided at their outer ends with governor-balls d', which are connected by a spring-tension device d^2 d^3, the spring d^2 of which may be adjusted so as to give any desired tension by means of the screw-threaded sections d^3. The inner ends of the governor-levers d work in a groove or channel d^4 of a hub d^5, which is loosely mounted, both for rotary and sliding motion, on the crank-shaft c' and is provided with a cam-flange d^6 at its inner end.

In the valve seat or passage a^9, which opens from the chamber a^8 in the cylinder-casting, is mounted an inwardly-opening puppet-valve f, the stem of which works outward through said casting and is provided with a nut f', between which and said casting is compressed a light coiled spring f^2, which normally tends to hold the said valve f closed. The tension of the spring f^2 may be properly adjusted by means of the nut f'. Inasmuch as the explosive mixture must pass through the seat a^9 and by the valve f, this valve may be termed the "admission-valve," although, as will later appear, the main function of this valve is to prevent the return flow of the explosive or exploded mixture which has been admitted into the cylinder.

The commingling-chamber proper, as well as an atomizer or spraying device which coöperates therewith, are located exterior of, but in communication with, the chamber a^8. As shown, the commingling-chamber comprises a hollow casting g, the chamber g' of which is in communication with the chamber a^8 through a collar or stub-pipe g^2, which serves to hold said casting in position. The upper end of the chamber g' is closed by a cap-nut g^3. The casting g is provided at the lower extremity of the chamber g' with a valve-seat g^4, which opens downward into the interior of the cap-section g^5, secured to said casting g. This cap-section g^5 is practically air-tight, except for a series of peripheral perforations g^6, and is provided with a loose perforated ring g^7, the perforations of which are adapted to be made to register with or to close said perforations g^6. Seated in the valve-seat g^4 is an inwardly-opening puppet-valve g^8, the stem of which works downward through the cap g^5 and is subject to the action of a spring g^9.

It will be noted that the valve-seat g^4 is extended downward below the valve g^8, so as to form a cavity g^{10}. The air is delivered from the cap-section g^5 through a multiplicity of annularly-arranged passages g^{11}, which discharge directly into the cavity g^{10} below the valve g^8. With this construction when the valve g^8 is opened by suction from the engine a multiplicity of small streams of air will be drawn through the extension g^{10} and valve-seat g^4, and a fine spray of oil will be drawn through the passage h' and commingled with said streams of air. In this manner the oil and air will be commingled or mixed in the most efficient manner.

The atomizer is formed by a hollow head h, the interior of which opens into the commingling-chamber g' through a small perforation h', formed in the valve-seat g^4 of the casting g and adapted to be closed by said valve g^8. As shown, oil-supply pipes h^2 communicate with the cavity of the head h and serve to keep the same supplied with oil.

h^3 h^4 h^5 indicate, respectively, the stem, dial, and lever of an ordinary graduating device for limiting the flow of the oil through the perforation h'.

Seated in the exhaust-passage a^{11}, which opens from the cylinder into the chamber a^{10}, is an inwardly-opening puppet-valve k, the stem of which works downward and outward through the cylinder-casting and is provided at its end with a nut or head k', between which and said casting is compressed a coiled spring k^2. This valve k, when operated by a suitable valve-gear, controls the exhaust of the engine. The tension of the spring k^2 should be considerably in excess of that of the tension of the spring f^2 of the admission-valve f, as will later become obvious. As shown, the exhaust from the engine is carried off by means of a pipe a^{13}, which opens from the chamber a^{10}.

The valve-gear, which in this preferred form of my invention is a reversible gear and is arranged to control the engine by the direct manipulation of the exhaust-valve k and indirectly to actuate the admission-valve f, will now be described. On the crank-shaft c', just to the left of the crank c and within the casing a', is secured a small spur gear or pinion n. To the left side of the casing a, just forward of the shaft-bearing c^2, is rigidly secured the bearing-bracket n', which projects inward toward the crank c and terminates in a hollow trunnion n^2. On this trunnion n^2 is mounted with freedom for rotary motion a spur-gear n^3, which is in engagement with the small wheel n and is in diameter twice that of the diameter of said wheel n. On the hub of the gear-wheel n^3 is loosely mounted a disk n^4, which on its outer face is provided with a cam-surface n^5. As shown, this cam-surface extends throughout about ninety degrees, or the quarter of a circle. The wheel n^3 is provided with a long slot n^6, which runs concentric to the center of said wheel, and the loose disk n^4 is provided with a pin or stop-lug n^7, which works through said slot n^6, projects to the inner side of said gear n^3, and is provided with a head or nut n^8. Between this head or nut n^8 and the inner face of the gear n^3 is pressed a flat spring n^9, which, while it permits the limited movement of the disk n^4 with respect to said gear n^3, presses the faces of the same together and causes them to move with respect to each other under a slight friction.

Mounted for reciprocating movement through the center of the bearing-bracket n' is a plunger n^{10}, the outer end of which projects outward toward the left side of the engine beyond said bracket n' and the case a'.

n^{11} is a stud-shaft which is rigidly secured to the plunger n^{10} and projects therefrom toward the front of the engine. This stud-shaft n^{11} is of course carried with the plunger n^{10} in its reciprocating motions, and the bracket n' is slotted, as shown at n^{12}, to permit this movement. At its forward end the stud n^{11} is provided with a loose antifriction-wheel n^{13}, which normally bears against the face of the disk n^4 and is adapted to be operated upon by the cam-surface n^5.

On the left side of the engine, exterior of the case a', mounted in bearings a^{14}, is a longitudinally-disposed rock-shaft n^{14}. On the rear end of this rock-shaft n^{14} is rigidly secured an arm n^{15}, the free end of which extends upward and normally presses against the outer end of the plunger n^{10}. On the front end of the rock-shaft n^{14} is rigidly secured another arm n^{16}, which projects laterally inward and underlies the depending stem of the exhaust-valve k. As shown, the free end of this arm n^{16} is provided with a set-screw n^{17}, which engages directly against the head k' of the stem of said valve k. By means of this set-screw the arms n^{15} and n^{16} may be so adjusted that in the normal position of the parts—that is, when the roller or wheel n^{13} bears against the face of the disk n^4—the exhaust-valve k may, under the action of its spring k^2, be held in its closed position, and at the same time the said spring k^2, acting through the intermediate connections, serves to hold the said wheel n^{13} in engagement with said disk n^4. When, however, the disk n^4 is so turned that its cam-surface n^5 engages and forces the wheel n^{13}, together with the plunger n^{10}, outward, the exhaust-valve k will, through the intermediate connections, be positively forced open against the action of its spring k^2.

A valve-retaining device, which is automatically operated by means of the governor already described, is also provided for holding the exhaust-valve in an open position during such times as the engine is run above a predetermined desired speed. As shown, this device comprises as follows: The free end of the arm n^{15} is provided with a projecting lip n^{18}. In bearings p, secured to the casing a', one on each side of the plunger n^{12}, is mounted a sliding bolt p', which is expanded and cut away at its central portion, so as to clear the outer end of the plunger n^{12}. This sliding bolt p' is spring-pressed to move toward the cam-collar d^5 on the shaft c' by means of a coiled spring p^2, and the inner end of the same is provided with an antifriction-roller p^3, which is adapted for engagement with the cam-flange d^6 of said collar d^5. As shown, the sliding bolt p' is also provided with a projecting finger p^4, which normally stands out of the line of movement of the lip n^{18} of the arm n^{15}, but which is adapted to be engaged thereby when moved toward the plunger n^{12}. When this finger p^4 is thrown into the path of and engaged by the lip n^{18}, the return movement of the levers n^{15} and n^{16} will be prevented, and hence the exhaust-valve k will be held in its open position, as will more clearly appear in the description of the operation of the engine.

In a suitable valve-seat s, which opens into the laterally-extended chamber a^{12} of the cylinder, is an inwardly-opening puppet-valve s', the stem of which projects outward and is subject to the action of a coiled spring s^2, which normally tends to hold said valve closed, but under such light tension that the valve may be readily opened by the suction of the piston. This valve-passage, as will later more clearly appear, affords an auxiliary device for affording a supplemental supply of fresh air into the cylinder.

The igniter or sparking device for causing the explosion of the explosive mixture within the cylinder will now be described.

One member of the electrodes of an electric sparker is carried by the piston b, and, as shown, is in the form of a projecting pin or finger t, located at the center of the working end of said piston-head. This electrode t, which, as shown, is indicated as the positive member, is normally electrically connected to the positive wire t' through a contact-piece t^2, which is insulated from the casing a' and terminates in a flat leaf-spring t^3, the free end of which normally engages behind the finger p^4 of the sliding bolt p'. From this finger p^4 and sliding bolt p' the current finds a path of extremely low resistance through the metallic portions of the engine to the said electrode t, carried by the piston-head. When the sliding bolt p', with its finger p^4, is moved into position to intercept the movement of the arm n^{15} and lip n^{18}, the circuit will be broken between said spring t^3 and said finger p^4 by means of a fixed insulated stop t^4, which intercepts the movement of the free end of the spring t^3 and prevents it from following the finger p^4. The other member (as indicated at the negative member) of the electrodes is in the form of a long horizontally-disposed leaf-spring t^5, the free end of which is adapted to be engaged by the end of the electrode t at the extreme movement of the piston-head toward the same, and the outer or fixed end of which is rigidly secured to a contact-head t^6. This contact-head t^6 is projected through the peripheral wall of the chamber a^{12} and is insulated therefrom, as well as from all other portions of the engine, by means of an insulation t^7. The negative member t^8 of the conductors or wires is directly secured to the head t^7 by means of a clamp t^9.

The operation of the machine is substantially as follows: Assume the engine to have been started to run in the direction indicated by the arrows marked on certain of the parts in Figs. 3, 8, and 9. As shown in Fig. 8, the crank-arm c has reached a point in its revolution within about ten degrees of its extreme outward throw. At this point the cam-surface n^5 on the disk n^4 has been turned just

into engagement with the wheel n^{13}, which is carried with the stud n^{11} and plunger n^{10} and by this engagement has, through the intermediate connections, just begun to force the exhaust-valve k into its open position. When the crank-shaft has traveled onward about one-quarter of a turn, the highest point of the cam-surface n^5 will be forced against the roller n^{13}, which will of course cause the extreme outward movement of the plunger n^{10} and the complete opening of the exhaust-valve k, as shown in Fig. 3. When the crank-shaft has traveled still farther onward to within about five degrees of its extreme inward movement, the cam-surface n^5 will have just been turned from engagement with the wheel n^{13}, as shown in Fig. 9, and the exhaust-valve k will have again been closed under the action of its spring k^2. It will thus be seen that this return movement of the piston-head b was made while the exhaust-valve k was open, and it may be here noted that this return stroke is that which immediately follows the outstroke of the piston which was caused by the explosion of the explosive mixture within the cylinder. Hence this return stroke serves to discharge or eject the exploded compounds or gases. In the movement of the wheel n^3, together with the cam-disk n^4, as just described, the end of the slot n^6 engaged the pin n^7 of the said cam-disk n^4, and thereby caused said cam-surface n^5 to move, as just described. Under the next half-revolution of the crank c from its extreme innermost to its extreme outermost throw the exhaust-valve k will be held closed by a spring k^2, and the outstroke of the piston b will produce or tend to produce a vacuum in the cylinder back of the piston. The suction produced by the vacuum thus formed will overcome the spring f^2 of the admission-valve f, thereby opening said valve and in like manner also the valve g^7 in the commingling-chamber g. The valves being thus opened by suction, a spray of oil will be drawn from the atomizer or head h through the perforation h', and more or less fresh air will be sucked in through the coincident perforations of the cap g^5 and of the ring g^7. The air and oil thus sucked into the commingling-chamber g will be thoroughly mixed or commingled before entering the cylinder of the engine, but will subsequently be drawn into the cylinder. Under this same outward stroke of the piston b the auxiliary valve s' in the valve-seat s will also be opened by suction and a supplemental or additional supply of fresh air will be sucked into the cylinder through said seat s. This feature of construction is of great importance in the practical operation of the engine. This additional amount of air insures a sufficient amount of oxygen within the cylinder to render the explosion and decomposition of the gas complete. Incidentally it should be noted that this inflow of fresh air through the valve-seat s passes over the leaf-spring or electrode t^5. This feature, however, is extremely desirable, as it tends to keep the spring cool or prevents the same from losing its temper by the extreme heat caused by the explosion of the gas. The next half-revolution of the crank c and inward stroke of the piston b will compress the gas or explosive mixture which is confined in the cylinder. At the limit of the piston's inward movement the electrodes t and t^5 will be thrown together to complete the circuit through the electric connections, and as the said electrodes are separated an electric spark or arc will be formed, which will ignite the gases or explosive mixture which are compressed within the cylinder back of the piston. This explosion will of course hasten the outward movement of the piston. During the last three strokes of the piston b or revolution and a half of the crank c the large gear n^3 was turned three-quarters of a revolution, throughout which movement the wheel n^{13} remained in engagement with the face of the disk n^4, and hence the exhaust-valve k all this time remained closed.

It is extremely important to here note that the valve f in the passage a^9 also remains closed under the last-noted outstroke of the piston caused by the explosion of the explosive mixture, thereby positively preventing any return of the exploded gases or compounds into the commingling-chamber. These products of the explosion, if allowed to return into the commingling-chamber, would do great damage by stopping and clogging the small oil and air passages of the spraying device and attachments. As already described, the next inward stroke of the piston will be effected while the exhaust-valve k is opened.

If at any time in the operation of the engine the speed of the same is increased beyond the predetermined desired velocity, the governor-balls d' will by the action of centrifugal force be thrown apart, and the levers d will thereby be caused to draw the collar d^5 outward on the crank-shaft c'. Under this outward movement of the collar d^5 the cam-flange d^6 of the same will be drawn against the roller p^3 of the sliding bolt p', thereby carrying the finger p^4 under or in the path of the ear n^{18} of the arm n^{15}. This, as already described, will prevent the return movement of the lever n^{15} and connected parts and will hold the exhaust-valve k open until the velocity of the engine has been reduced, at which time the collar and cam d^5 d^6, being thrown to their normal positions, will permit the return movement of the bolt p' and finger p^4. The lever n^{15} being thus released, the exhaust-valve k will of course be again closed by the action of its spring k^2.

It will be understood, of course, that when the exhaust-valve k is held open the outward stroke of the piston b will not create a vacuum or sufficient suction in the cylinder to open the admission-valve f. Hence while the exhaust-valve remains open a fresh supply of the explosive mixture will not be drawn into the cylinder.

Attention is also recalled to the fact that as the sliding bolt p' was forced forward by the action of the governor and sliding cam-sleeve d^5 d^6 the electric circuit was broken between the spring t^3 and the finger portion p^4 of said bolt p' by means of the insulating-stop p^4. Hence while the exhaust-valve was held open by the governor under an excessive speed of the engine the sparking action at the electrodes t and t^5 was also stopped or suspended. This of course saves the battery or other electric energy which may be used to produce the sparking action.

The reversible feature of the valve-gear will now be explained. The slot n^6 in the gear n^3 is of such length that when the crank c is given a reverse movement from that just described or is turned, as indicated by the arrows in Figs. 10 and 11, and is brought to a position indicated in Fig. 10 the cam-disk n^4 will move on said wheel n^3 until the pin n^7 strikes the opposite extremity of said slot a^6, at which time one end of the cam-surface n^5 will be thrown just barely into engagement with the antifriction-wheel n^{13}. Like Fig. 8, Fig. 10 illustrates the relation of the parts when the crank c has been turned to within about ten degrees of its extreme outward throw, but under a reverse movement of the engine from that indicated in said Fig. 8. Evidently the actions which will now follow as the crank c continues to revolve will be the same as those described in connection with the reverse movement of the engine. For instance, as the crank is given approximately its first half-turn and the piston moved to its extreme innermost position the cam-surface n^5 will have just left the wheel n^{13}, as shown in Fig. 11, and the exhaust-valve k will be completely closed.

From the above it must be obvious that with a reversing-gear constructed on the principle described a gas or explosive engine may be run in either direction without alteration of the parts of the engine. The engine shown will run in either direction in which it is started, inasmuch as the slot-and-pin engagement n^6 n^7 between the wheel n^3 and the cam-disk n^4 will permit said parts to slip one upon the other. The device shown is therefore automatic in its reversing action. However, connections might be applied to the cam-disk or equivalent device by means of which the same might be positively shifted at the will of the operator, and this would be clearly within the scope of my invention.

Attention is called to the fact that as the commingling-chamber g' and valve-chamber a^8 are located exterior of the valve f and inward of the oil-spraying and air-supply devices, which form part of the commingling device, a considerable amount of the commingled explosive mixture is kept on hand ready to be sucked into the cylinder on the suction stroke of the piston.

It will be understood, of course, that various alterations in the details of construction of the devices above described may be made without departing from the spirit of my invention.

What I claim, and desire to secure by Letters Patent of the United States, is as follows:

1. In an explosive-engine, a reversible valve-gear involving a cam-operated part, a rotary disk or part, and a cam-acting trip-block mounted for a limited circular movement with respect to said rotary disk or part, and so related thereto that when shifted into its extreme positions, it will operate on the valve or valves controlling the admission and exhaust of the explosive mixture, so as to time said valve-gear to run the engine in reverse directions, substantially as described.

2. The combination with the cylinder and piston, of a commingling-chamber exterior of said cylinder but in communication therewith, inlets for the admission of the liquid fuel and fresh air to said commingling-chamber, an auxiliary air-port opening directly from the atmosphere into said cylinder, an inwardly-opening valve normally closing said auxiliary fresh-air port, and a spring constituting one member of the igniter-electrodes, located directly in the line of the inward fresh-air draft from said auxiliary fresh-air port.

3. In an explosive-engine, the combination with the cylinder and piston, of a passage leading to said cylinder through a valve block or casting which is provided with the valve-seat g^4 with bottom extension g^{10}, the multiplicity of air-passages g^{11}, leading to said extension g^{10}, the passage h' opening through said valve-seat g^4, and the valve g^8 coöperating with said seat g^4, substantially as described.

4. In an explosive-engine, the combination with the cylinder and piston, of the commingling-chamber g' and casting g, which casting g is provided with the valve-seat g^4 with extension g^{10}, the multiplicity of air-passages g^{11} opening to said extension g^{10} and the oil-passage h' opening to said seat g^4, and the valve g^8 coöperating with said seat g^4, substantially as described.

5. In an explosive-engine, the combination with the crank-shaft, of a governor-controlled sliding cam-collar mounted on said crank-shaft, an exhaust-valve controlling the exhaust from the engine, a valve-gear for controlling said exhaust-valve, and a sliding bolt operated by the sliding movement of said cam-collar to lock said valve-gear or certain parts thereof in position to hold said exhaust-valve open.

In testimony whereof I affix my signature in presence of two witnesses.

LARS HALVORSON.

Witnesses:
JORGEN OLSON,
G. P. KARWAND.